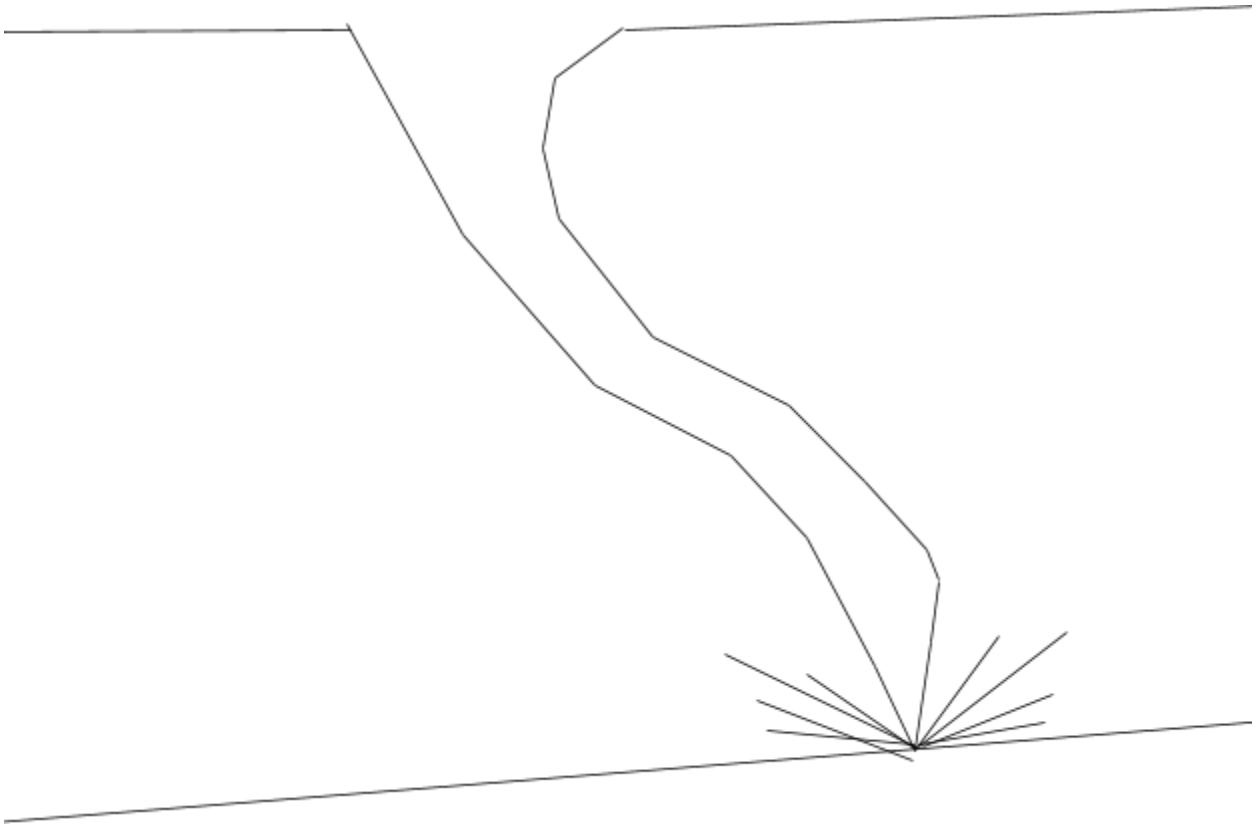
Book of Tornado Intensity

Full rating assessment from EF 0 to EF 5



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Introduction

What is a tornado? Although frequently confused with a cloud, a tornado is actually a violently rotating column of air that extends from the base of a thunderstorm to the ground. While most are weak and cause minimal damage, the most severe tornadoes can produce wind speeds exceeding 200 mph. Such examples are the 1999 Bridge Creek F5 tornado that produced catastrophic damage.

Difference between F and EF scale

The Fujita (F) scale served as the standard tornado rating system from 1971 until 2007. Although developed in 1971, the scale was applied retroactively to rate significant tornadoes that occurred between 1950 and 1970.

The EF Scale, or Enhanced Fujita Scale, rates tornado intensity from EF0 to EF5 based on the damage they cause, estimating wind speeds by assessing damage to buildings and vegetation. Introduced in 2007, it replaced the original Fujita Scale to better correlate wind speeds with observed destruction, using 28 damage indicators (like roofs, trees, power poles) and 8 damage levels to determine the rating.

Storm Forcasting

Meteorologists across the United States utilize a sophisticated network of technology to differentiate between routine rainstorms and severe weather capable of spawning tornadoes. While standard rain is easily tracked, identifying a tornado requires a deeper look into the atmospheric "ingredients" and the internal structure of a storm. To predict severe weather, meteorologists look for four primary "ingredients" often remembered by the acronym SLIM: Shear, Lift, Instability, and Moisture. Moisture acts as the fuel, while instability provides the energy for warm air to rise rapidly into the cooler upper atmosphere. A lifting mechanism, such as a cold front or mountain range, provides the initial "nudge" to start this upward movement. For a storm to become tornadic, wind shear—a change in wind speed or direction with height—is critical; it creates horizontal rotation that a strong updraft can tilt vertically. This process transforms a standard thunderstorm into a supercell, a highly organized storm characterized by a rotating internal structure known as a mesocyclone. Within this structure, features like the wall cloud and the rear flank downdraft work in tandem to tighten and descend this rotation toward the ground, ultimately culminating in the formation of a tornado.

Intensity Rating

In the United States, tornado intensity is officially classified using the Enhanced Fujita (EF) Scale, which was adopted on February 1, 2007, to replace the original 1971 Fujita Scale. This modern system rates a tornado based on the estimated three-second wind gusts derived from the severity of observed damage, rather than direct wind measurements, which are rarely available due to the destruction of weather instruments during such events. To determine an official rating, National Weather Service (NWS) meteorologists conduct thorough post-storm surveys, comparing wreckage against 28 specific Damage Indicators—including various building types like schools, mobile homes, and high-rise structures, as well as vegetation like trees—and 8 "Degrees of Damage" that range from minor visible damage to total destruction.

As of 2025, the scale categorizes tornadoes from EF0 to EF5, with EF0 representing weak intensity (65–85 mph) causing minor damage like broken branches, and EF1 (86–110 mph) resulting in moderate damage such as overturned mobile homes. Higher ratings like EF2 (111–135 mph) and EF3 (136–165 mph) denote strong tornadoes capable of tearing roofs off well-built homes or destroying entire stories. The most catastrophic levels, EF4 (166–200 mph) and EF5 (over 200 mph), are classified as violent; an EF5 tornado, for instance, can sweep homes entirely off their foundations and critically damage steel-reinforced structures. Notably, in June 2025, a tornado in Enderlin, North Dakota, was rated EF5, marking the first such rating in the United States in over 12 years. If a tornado occurs in a remote area without surveyable structures to provide a clear rating, it may be designated as EF-Unknown (EFU).

-Elliott

EF 0

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An EF0 tornado represents the least intense classification on the Enhanced Fujita (EF) Scale, characterized by estimated wind speeds ranging from 65 to 85 mph. These events, which account for approximately 35% to 40% of all annual tornadoes in the United States, are often brief and may not even produce a visible funnel cloud. Despite being labeled "weak," an EF0 can still cause measurable disruption, such as peeling shingles or siding from homes, damaging gutters, and breaking branches off trees. In some cases, shallow-rooted trees may be uprooted, and large signs or fences can be toppled. For example, an EF0 that struck Los Angeles on Christmas Day 2025 damaged commercial signs, shattered windows at a strip mall, and caused roof leaks at residential properties.

Meteorologically, EF0 tornadoes typically form from low-topped mini-supercells or within linear storm systems where rotation is present but less robust than in higher-intensity events. These storms develop in unstable atmospheric conditions where wind shear—the change in wind speed or direction with height—allows a spinning column of air to tilt vertically and touch the ground. Because their damage is superficial, such as scattered debris and minor structural scarring, National Weather Service surveyors sometimes find it difficult to distinguish an EF0 path from straight-line wind damage. If a confirmed tornado occurs in an open field without hitting any "damage indicators" like buildings or trees, it is often defaulted to an EF0 rating or designated as EFU (Unknown). Safety remains paramount during these events, as even low-velocity winds can propel dangerous small debris at speeds sufficient to cause injury.
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EF 1

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Categorized as "weak" on the Enhanced Fujita Scale, an EF1 tornado is a formidable atmospheric phenomenon characterized by estimated three-second wind gusts ranging from 86 to 110 miles per hour. Despite the "weak" classification, these storms represent a significant escalation in destructive potential from the lower EF0 tier, primarily because their wind speeds are sufficient to cause moderate structural damage. In residential areas, an EF1 tornado typically manifests its power by severely stripping roofing materials from frame houses, often peeling away shingles, gutters, and vinyl siding. More critically, these storms can exert enough pressure to tear off the edges or corners of a roof, a failure that often compromises the structural integrity of the home by allowing wind to pressurize the interior. This process can lead to the loss of exterior doors and the shattering of windows, which further exposes the inhabitants to flying glass and debris. The impact on mobile homes is particularly devastating; while well-built permanent structures might remain largely intact, mobile homes are frequently overturned, pushed off their foundations, or even completely destroyed by the force of an EF1's winds.

Beyond structural impacts, the EF1 tornado significantly alters the landscape and poses serious risks to vehicles and infrastructure. Surveyors often identify these tornadoes by the presence of multiple snapped trees—a damage indicator typically associated with wind speeds of at least 93 mph. These fallen trees frequently block roads and can lead to secondary emergencies, such as a 2025 incident in Mississippi where a train collided with a tree downed by an EF1 tornado. In terms of transportation, the force of an EF1 is strong enough to push moving cars and trucks off the road or even flip them entirely, making vehicles highly dangerous places to seek shelter. In the agricultural and commercial sectors, these storms are known to tear roofs off large silos, destroy outbuildings, and strip the wood sheathing from warehouse structures. Throughout 2025, numerous documented EF1 events across states like Alabama, Mississippi, and Michigan have underscored that these tornadoes, which account for approximately 35% of all annual tornadoes in the U.S., remain life-threatening despite sitting at the lower end of the intensity scale. Unlike more violent tornadoes that may have longer paths, weak tornadoes like the EF1 typically last less than 10 minutes, yet their rapid onset and ability to generate windborne missiles necessitate immediate and robust safety measures.
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EF 2

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An Enhanced Fujita Scale Category 2 (EF2) tornado represents a significant threshold in meteorological violence, characterized by wind speeds ranging from 111 to 135 miles per hour (179 to 217 kilometers per hour). At this intensity, the atmospheric vortex transitions from causing superficial property damage to inflicting structural failures that can permanently alter a landscape. The kinetic energy within an EF2 funnel is sufficient to tear well-constructed roofs completely off frame houses, leaving the interior rooms exposed to the torrential rain and debris-laden winds that typically accompany such supercellular events. Beyond residential structures, these tornadoes possess the torque required to shift or collapse the foundations of small businesses and outbuildings. In suburban environments, the visual signature of an EF2 strike is often defined by the "missile" effect, where everyday objects like backyard furniture, fence posts, and shingles become lethal projectiles capable of piercing through reinforced siding or shattering tempered glass. The sheer force of the pressure gradient can lift light vehicles off the ground or tumble them across parking lots, while larger transport trucks may be blown off highways. This level of wind force is also the point where the natural canopy suffers irreparable harm; massive hardwood trees, which may have stood for a century, are often snapped like matchsticks or completely uprooted, potentially blocking emergency access routes and severing overhead utility lines for entire neighborhoods.

The sociological and engineering implications of an EF2 tornado are profound, as this category often serves as the "stress test" for modern building codes and community resilience. While an EF0 or EF1 might result in manageable insurance claims for minor shingle loss, an EF2 event often triggers total-loss assessments for mobile homes, which are frequently demolished or overturned even when anchored. For structural engineers, the EF2 rating is a critical benchmark because it highlights the vulnerability of the "roof-to-wall" connection; most catastrophic failures at this speed occur because the uplift forces exceed the gravity loads and mechanical fastening of the trusses. Consequently, a town struck by an EF2 tornado faces a complex recovery period that involves not just debris removal, but a massive logistical overhaul of the power grid and communication infrastructure. The psychological impact on a community is equally heavy, as the sound of an EF2—often described as a low-frequency roar similar to a freight train—coincides with the physical sensation of a building vibrating under extreme wind load. Survivors often report the terrifying transition of their homes "breathing" as internal pressures fluctuate wildly before the structural envelope is breached. Because EF2 tornadoes account for a significant portion of significant tornado-related injuries, they remain a primary focus for National Weather Service meteorologists who utilize dual-polarization radar to detect the "debris ball" that forms when these winds begin lofting heavy material into the sky, signaling a life-threatening escalation from a minor gale to a destructive atmospheric engine.
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EF 3

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An EF3 tornado, a formidable and destructive force of nature, represents a significant escalation from its weaker counterparts on the Enhanced Fujita Scale. With estimated wind speeds ranging between 136 and 165 mph, these tornadoes possess the raw energy to cause severe devastation, fundamentally altering the landscapes and communities they traverse. Unlike EF0 or EF1 tornadoes, which often result in minor structural damage like shingle loss or snapped tree limbs, an EF3 tornado inflicts grave, widespread destruction. Homes with good foundations are often severely compromised, experiencing the loss of entire roofs and some exterior walls, while weaker structures are likely to be leveled completely. The integrity of well-built schools or large commercial buildings is put to the test, with significant damage to load-bearing walls becoming commonplace. This level of intensity means that mobile homes, vehicles, and even large trucks can be picked up and thrown considerable distances, becoming deadly projectiles in the process. The path of an EF3 is not just about isolated damage; it involves a broad swath of concentrated, high-impact force that fundamentally reshapes the built environment, making recovery a lengthy and resource-intensive endeavor for the affected communities. The visual aftermath of such a storm is one of profound chaos and ruin, a stark testament to the sheer power of atmospheric instability.

The mechanics behind the formation and the sheer power of an EF3 tornado involve complex atmospheric dynamics, a convergence of conditions that create a volatile environment capable of producing such intense rotating columns of air. This process typically begins within a supercell thunderstorm, a massive, long-lived storm characterized by a deep, persistent rotating updraft known as a mesocyclone. The presence of significant wind shear—a change in wind speed and direction with height—is a critical ingredient, helping to initiate and sustain this rotation. As the mesocyclone tightens and intensifies, a visible condensation funnel can descend from the storm's base, eventually making contact with the ground to become a full-fledged tornado. The EF3 rating is assigned post-event, based on meticulous damage surveys conducted by meteorologists and engineers from entities like the National Weather Service. These experts examine the type of damage inflicted on specific, well-defined indicators, cross-referencing this with the estimated wind speeds required to cause such destruction. This damage-based assessment provides a standardized metric for rating the tornado's intensity, ensuring consistency across different events. The experience of an EF3 tornado is terrifying; the deafening roar, often compared to the sound of a freight train, is accompanied by immense pressure changes and the terrifying spectacle of buildings and infrastructure disintegrating in seconds. Understanding these storms is crucial for improving warning systems and building more resilient communities capable of withstanding the formidable power of extreme weather events.
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EF 4

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An EF4 tornado represents a pinnacle of atmospheric violence, characterized by 3-second wind gusts ranging from 166 to 200 mph (267 to 322 km/h) that can turn ordinary objects into lethal projectiles and reduce substantial structures to unrecognizable debris. These devastating events are typically spawned by mature supercell thunderstorms, which possess powerful, rotating updrafts known as mesocyclones. The formation of such a violent vortex requires a precise convergence of atmospheric ingredients: extreme instability fueled by warm, moist air near the surface, significant vertical wind shear that facilitates rotation, and a lifting mechanism such as a cold front or dryline. As the storm intensifies, a rear-flank downdraft (RFD) often descends, wrapping around the mesocyclone and focusing its angular momentum toward the ground. This process can create a broad, multi-vortex core where smaller, intense suction spots orbit the main funnel, further concentrating the destructive energy. The sheer force of an EF4 is sufficient to debark trees completely, leaving only skeletal stubs, and to strip asphalt from roadways or ground-scour topsoil. Meteorologically, the transition from a strong EF3 to a violent EF4 is marked by the total failure of structural integrity in even the most robust residential buildings, which are often leveled rather than merely losing their roofs and walls.

The human and engineering impact of an EF4 tornado is profound, as the Enhanced Fujita Scale uses 28 specific damage indicators to assess the intensity based on the failure of various building types. While an EF3 might leave a pile of rubble on a foundation, an EF4 often scatters that debris for miles, leaving nothing but a clean slab behind. Well-constructed, anchor-bolted frame houses can be completely flattened, and large commercial structures like shopping malls or industrial plants frequently suffer catastrophic structural collapse. Vehicles are no longer merely rolled; they are lofted high into the air and thrown considerable distances, sometimes becoming mangled beyond recognition several hundred yards from their original locations. Historical examples, such as the 2013 Washington, Illinois tornado or the 2016 Funing tornado in China, illustrate the immense economic and social toll of these events, which can cause hundreds of millions of dollars in damage and result in significant loss of life despite modern warning systems. In community-wide impacts, the sheer width of an EF4—sometimes exceeding a mile—can result in the simultaneous destruction of entire neighborhoods, leaving long-term scars on the local economy and landscape. Because the wind speeds of an EF4 overlap with the lower threshold of the "incredible" EF5 category, storm surveyors must meticulously examine debris patterns and foundation attachments to distinguish between devastating and total "swept away" destruction.
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EF 5

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The Enhanced Fujita Scale's highest designation, the EF5 tornado, represents the absolute pinnacle of atmospheric violence, characterized by estimated three-second wind gusts exceeding 200 miles per hour. These rare meteorological monsters are not merely storms but engines of total terrestrial transformation, capable of altering the physical geography of the landscape they traverse. When a supercell thunderstorm produces a vortex of this magnitude, the traditional survival strategies of seeking interior rooms often prove insufficient, as the structural integrity of standard wood-frame or even reinforced masonry homes is systematically compromised. An EF5 tornado possesses the kinetic energy to sweep well-anchored residences completely off their concrete slabs, leaving nothing behind but bare foundations and severed utility pipes. The sheer pressure differentials and high-velocity debris—which can include heavy vehicles, structural steel beams, and appliances transformed into supersonic projectiles—create a scouring effect that can strip asphalt from roadbeds and debark mature hardwood trees until only skeletal trunks remain. This level of destruction is often described by forensic meteorologists as "ground scouring," where even the topsoil is vacuumed into the cyclonic flow, leaving behind a scarred earth that serves as a grim testament to the storm's unfathomable power.

The atmospheric conditions required to generate such a catastrophic event involve a precise and volatile alignment of instability, moisture, and extreme vertical wind shear. Typically, these vortices emerge from "high-precipitation" or "classic" supercells where the rotating updraft, or mesocyclone, becomes so intense and concentrated that it collapses toward the surface, tightening its radius and exponentially increasing its rotational velocity through the conservation of angular momentum. Beyond the immediate physical impact, the legacy of an EF5 tornado is defined by its profound sociological and psychological toll on the communities it strikes. In the aftermath of legendary storms like those in Joplin, Missouri, or Moore, Oklahoma, the sheer scale of the debris field creates a logistical nightmare for emergency responders, as recognizable landmarks are obliterated, rendering GPS and traditional navigation useless. The recovery process for such a disaster spans decades, involving not just the reconstruction of infrastructure but the reconciliation of a community's collective identity with the memory of a landscape redefined in a matter of seconds. The terrifying majesty of the EF5 remains the ultimate challenge for modern engineering and meteorology, standing as a reminder of the fragility of human civilization when confronted by the most extreme manifestations of the Earth's convective energy.
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EF U

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The EF-U rating, or "EF-Unknown," represents the most enigmatic classification within the Enhanced Fujita Scale, serving as a critical placeholder for tornadoes that elude traditional intensity estimation due to a complete lack of damage indicators. While the scale typically relies on the destruction of human-made structures or specific vegetation patterns to infer wind speeds, an EF-U designation is applied when a tornado occurs over a region devoid of such markers, such as open prairies, desolate desert basins, or dense, unmonitored marshlands. This classification is not a reflection of the storm's actual physical potency but rather a limitation of the current surveying methodology, which requires a "damage indicator" to assign a numerical value from zero to five. In many instances, a tornado may exhibit terrifying visual characteristics, such as a massive "wedge" shape or a debris ball on dual-polarization radar, yet if it fails to strike a barn, power pole, or stand of trees, meteorologists from the National Weather Service are professionally obligated to record it as EF-U. This creates a fascinating paradox in the historical record where a potentially catastrophic atmospheric event is relegated to a non-numerical status simply because its path did not intersect with the built environment. Consequently, the EF-U rating highlights the anthropocentric nature of our storm intensity scales, reminding us that our understanding of tornado frequency and power is inextricably linked to where we choose to build our infrastructure, leaving a significant portion of tornadic activity effectively unquantified in the vast, uninhabited stretches of the Great Plains and beyond.

The implications of the EF-U rating extend deeply into the realms of climatological research and public safety policy, as these "invisible" storms complicate the long-term statistical analysis of tornado trends. When a significant portion of tornadoes are logged without an intensity rating, it skews the data used to determine if the frequency of violent tornadoes is increasing or shifting geographically, a phenomenon often referred to as "Dixie Alley" expansion. To mitigate this data gap, researchers are increasingly looking toward remote sensing technologies and mobile Doppler radar units, which can measure wind velocities directly within the vortex rather than relying on post-storm wreckage. If a mobile radar records wind speeds exceeding 200 miles per hour over an empty wheat field, there is a growing debate within the meteorological community about whether that storm should be retroactively assigned an EF-5 rating despite the lack of structural damage. However, the official Enhanced Fujita Scale guidelines currently prioritize ground-truth damage over radar-derived measurements to maintain historical consistency. This tension between observational technology and traditional surveying methods ensures that the EF-U remains a controversial and heavily scrutinized category. Furthermore, for insurance companies and emergency management agencies, the EF-U classification can pose challenges in assessing risk zones, as a "zero-damage" history in a rural county might falsely suggest a lower risk of violent winds. As we move further into the 21st century, the integration of high-resolution satellite imagery and drone-based surveys may eventually shrink the number of EF-U occurrences, but for now, they stand as a haunting testament to the raw, unmeasured power of nature operating in the silence of the wilderness, far from the reach of human architectural fragility.
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